(12) UK Patent Application (19) GB (11) 2 134 984 A

(21) Application No 8403365
(22) Date of filing 8 Feb 1984
(30) Priority data
(31) 8301933
(32) 8 Feb 1983
(33) France (FR)
(43) Application published 22 Aug 1984
(51) INT CL[3] F15B 1/047
(52) Domestic classification
F1D P18A
F4P 303 AB
(56) Documents cited
GB 1206250
GB 1089996
GB 0948675
GB 0923010
(58) Field of search
F1D
F4P

(71) Applicants
Olaer Industries SA,
(France),
16 Rue de Seine,
Colombes (Hautes de Seine),
France
(72) Inventor
Jean Pierre De Loof
(74) Agent and/or Address for Service
Reddie & Grose,
16 Theobalds Road,
London WC1X 8PL

# (54) Composite pressure vessel

(57) A pressure vessel such as a hydropneumatic accumulator has a double wall comprising an internal liner 10 reinforced by an adjacent external casing 11. The external casing 11 is adapted on its own to provide almost all the mechanical strength of the double wall 10, 11. The Young's modulus of the internal liner 10 is much lower than that of the external casing 11. The internal liner 10 is advantageously made of elastomer and primarily performs a sealing function. The external casing may comprise filaments of glass, graphite or polyamide and a binder of epoxy resin, polyester or polyimide.

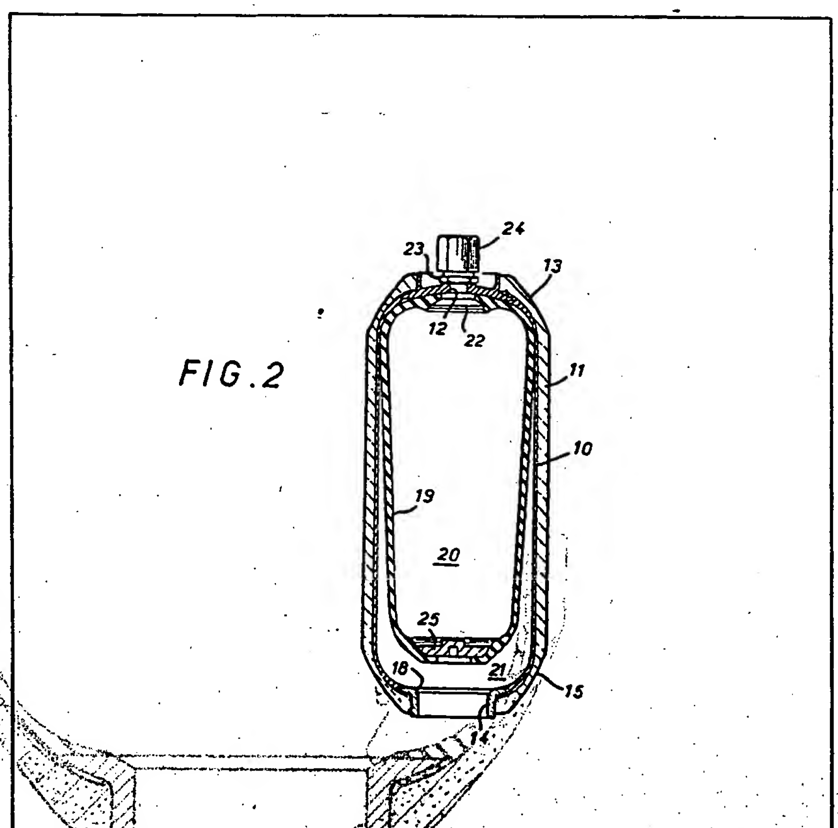



FIG. 2

GB 2 134 984 A

2134984

1/2

FIG. 1

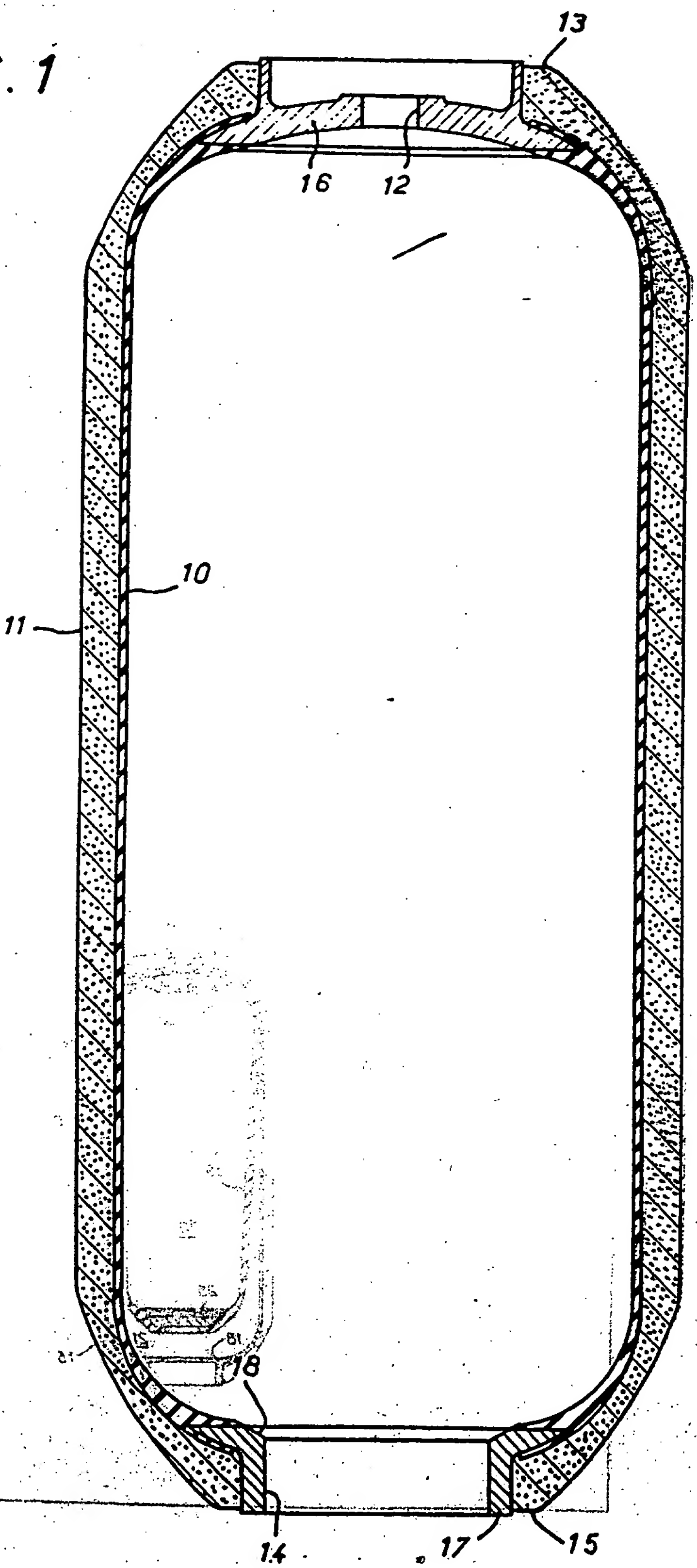


FIG. 2

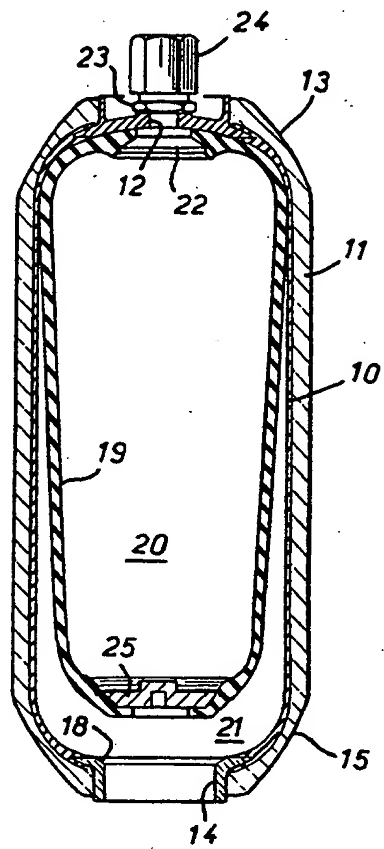
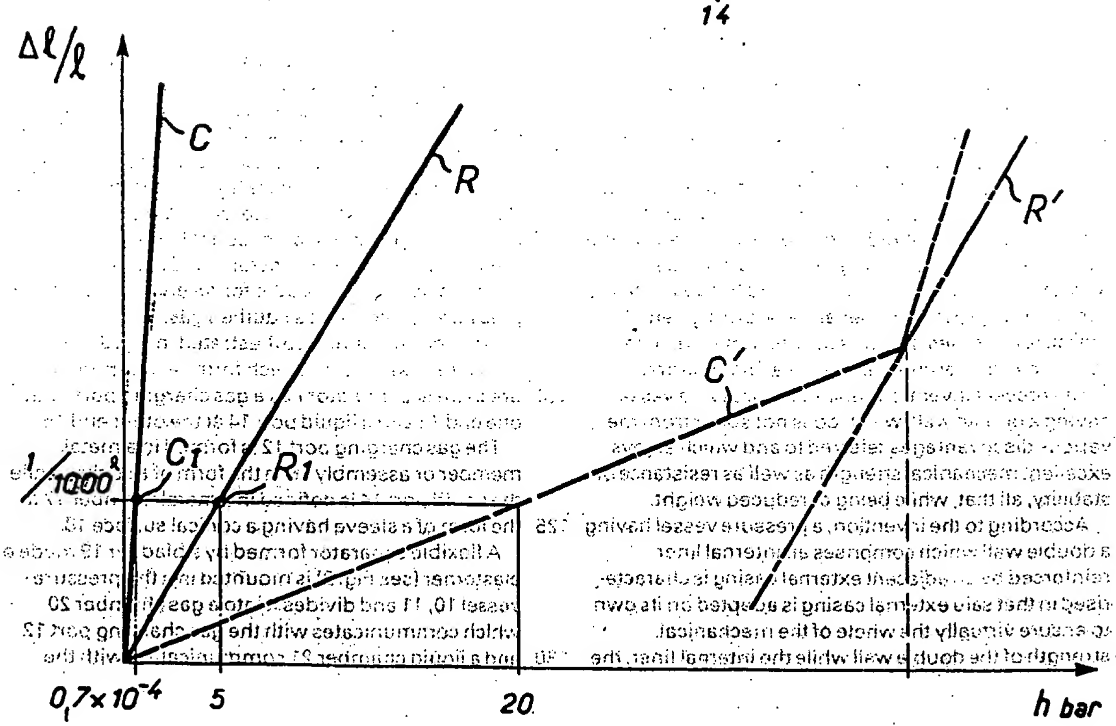

24
23
13
12
22
11
10
19
20
25
21
18
15
14

FIG. 3


Δℓ/ℓ
C
R
R'
C'
C1
R1
1/1000
0,7×10^-4
5
20
h bar

SPECIFICATION

**Composite pressure vessel**

The present invention relates to a pressure vessel, that is to say, a vessel which is intended to contain one or more fluids under pressure, at a constant pressure or a pressure which is variable in the course of time. The vessel may be a bottle, or a hydropneumatic pressure accumulator or a pressure transmitter or any vessel which is subject to fatigue by virtue of the internal pressure which may be a high pressure, for example several hundreds of bars, and, if appropriate, by virtue of variations in the internal pressure which, for example in the case of an accumulator, in the course of operation thereof, may range from a given pressure to three times that pressure and even higher.

In regard to pressure containers of that kind, a reduction in weight is desirable but it is important not to run the risk of compromising mechanical strength and resistance of the pressure container and additional elements that it may comprise, for example a flexible separator in the case of a hydropneumatic pressure accumulator, in which such a separator divides the space inside the pressure vessel into a gas chamber and a liquid chamber.

The present invention relates more particularly to a pressure vessel in which the wall thereof is at least double for the purposes of reducing the weight of the container without detrimentally affecting its mechanical strength or its resistance, the double wall comprising an internal liner reinforced by an adjacent external coating or casing.

The Young's modulus of such a material, as measured in hectobars (hbar) corresponds to the load in decaNewtons, under the effect of which a bar of that material, with a section of 1 mm$^2$, would undergo elongation by its own length. The more elastic the material, the lower the modulus. The Young's modulus of steel is of the order of 20,000 hbars while the Young's modulus of a winding of fibres encased in a binder is of the order of 5,000 hbars. In other words, the internal steel liner is 4 times less elastic than the external casing consiting of a winding of fibres encased in a binder. In certain circumstances, that can be an obstacle to achieving optimum conditions in respect of mechanical strength of the double wall, for the minimum possible weight thereof. Such an arrangement also suffers from the disadvantage of the danger of suffering buckling of the internal steel liner when the pressure vessel is subjected to substantial variations in pressure, for example from a given pressure to 3 times that pressure, in particular in the case of hydropneumatic pressure accumulators.

The present invention concerns a pressure vessel having a double wall, which does not suffer from the various disadvantages referred to and which enjoys excellent mechanical strength as well as resistance or stability, all that, while being of reduced weight.

According to the invention, a pressure vessel having a double wall which comprises an internal liner reinforced by an adjacent external casing is characterised in that said external casing is adapted on its own to ensure virtually the whole of the mechanical strength of the double wall while the internal liner, the Young's modulus of which is selected at a lower value than that of the external casing, primarily performs a sealing function.

By virtue of this arrangement, the internal liner is more elastic than the external casing and is therefore not subject to the danger of experiencing permanent deformation or buckling and retains excellent resistance or stability, irrespective of the pressure conditions within the vessel, being constant or variable, the external casing on its own and in all circumstances providing the mechanical strength of the double wall.

Preferably, the internal liner is of an elastomer. Good results are obtained with such a material for manufacture of the double wall, in the course of which the linear is fitted onto a mandrel which is either expansible or is a lost-material mandrel, for example of sand or wax, and then the fibres encased with binder are wound around the said elastomer liner.

Further, the fact that the liner used is of elastomer provides an excellent sealing action and, in the case of an accumulator, improves the conditions for its flexible separator.

In accordance with another feature, the thickness of the external casing is from twice to 10 times and preferably close to 6 times the thickness of the internal liner.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is a view in longitudinal section of a double-wall pressure vessel according to the invention,

Figure 2 is a view of the vessel shown in Fig. 1 on a smaller scale, provided internally with a flexible separator to form a hydropneumatic accumulator, and

Fig. 3 is a diagram illustrating the performance of the subject of the invention.

In the embodiment illustrated by way of non-limiting example in Figs. 1 to 3, Fig. 1 shows a pressure vessel having a double wall 10, 11. The double wall comprises an internal liner 10 reinforced by an adjacent external coating or casing 11. The pressure vessel is intended to be used as a hydropneumatic accumulator (Fig. 2) in which the internal pressure can vary within wide limits, for example ranging from a given pressure to a pressure three times that pressure. However, the pressure vessel according to the invention may be put to any other suitable uses in which the pressure is variable or constant, and it may for example be used as a bottle for receiving a fluid under pressure, for example a liquified gas.

In the non-limiting use illustrated in Fig. 2, the pressure vessel 10, 11 which forms a hydrpneumatic pressure accumulator has a gas charging port 12 at one end 13 and a liquid port 14 at the other end 15.

The gas charging port 12 is formed in a metal member or assembly 16 in the form of a socket while the liquid port 14 is defined in a metal member 17 in the form of a sleeve having a conical surface 18.

A flexible separator formed by a bladder 19 made of elastomer (see Fig. 2) is mounted in a the pressure vessel 10, 11 and divides it into a gas chamber 20 which communicates with the gas charging port 12 and a liquid chamber 21 communicating with the

liquid port 14.

The elastomeric bladder 19 carries a gas charging valve body 22 which is adapted to be mounted in the port 12. The valve body 22 is apertured for the purposes of charging the chamber 20 with gas and, screwed thereto, receives a nut 23 and a cap 24 for locking the body 22 in position and holding the member 19 in the container 10, 11.

Opposite to the valve body 22, the elastomeric bladder 19 carries, fixed with respect thereto, a button valve member 25 which is adapted to be closingly applied to the control surface 18 forming a seat.

The port 14 is intended to be connected to a hydraulic line, for example by a downward extension of the metal member 17.

For the purposes of operation of the pressure container, gas is first injected under pressure through the valve body 22 into the chamber 20, whereby the member 19 is applied against the wall 10, 11 of the container and urges the button member 25 into the closed position against the seat 18.

When liquid is introduced from the hydraulic line through the aperture 14 under a pressure higher than the preloading pressure of the gas in the chamber 20, the liquid flows into the chamber 21 by displacing the button member 25 away from the seat 18, and compressing the member 19. The hydropneumatic accumulator is then in its operative condition. In the course of operation, the pressure vessel 10 and 11 will carry substantial pressures, for example of the order of several hundreds of bars. Those pressures may vary within wide limits, for example from a given pressure value to a pressure three times that value. To give a specific idea in that respect, the preloading pressure of the accumulator may be of the order of 100 bars while in the course of operation the pressure may reach 300 or 400 bars.

It is therefore essential that the wall 10, 11 of the vessel is capable of withstanding under excellent conditions, pressures which are as high and which may possibly vary in such proportions, while being of minimum weight and while retaining excellent resistance and stability, both with regard to the assembly thereof and with regard to the various components thereof, that is to say, not only the liner 10 and the casing 11 but also the metal members 14 and 16, the valve body 22 and the elastomer bag member 19, as well as the button member 25.

In accordance with the invention, the external casing 11 is capable on its own of providing virtually all the mechanical strength of the double wall 10, 11 while the function of the internal liner 10 is primarily a sealing function.

The Young's modulus of a material, as measured in hectobars (hbars) is numerically equal to the load in decaNewtons under the effect of which a bar of that material, with a section of 1 mm$^2$, would undergo elongation by its own length. In other words, the more elastic a material is, the lower is the Young's modulus of that material.

In accordance with the invention, the material forming the internal liner 10 of the double wall structure 10, 11 has a Young's modulus which is lower than that of the material constituting the external casing 11. In other words, the internal liner 10 is more elastic than the external casing 11. In other words, the internal liner 10 is more elastic than the external casing 11. The internal liner 10 is therefore even more capable than the external casing 11 of undergoing deformation which does not run the risk of exceeding the limit of elasticity, above which such deformation would no longer be elastic but would become permanent.

Preferably, the internal liner 10 comprises an elastomer having a very low Young's modulus, for example of the order of 0.07 hbar.

The external casing 11 comprises fibres or filaments which are wound around the internal liner 10 (with the latter mounted on an expansible or lost-material mandrel) by techniques well known in the art, the fibres or filaments being encased or embedded in a binder. The fibres or filaments are for example glass or polyamide or carbon (graphite) fibres or even possibly asbestos, while the binder is for example a synthetic resin such as epoxy, polyester, polyimide or polyamide. The Young's modulus of the casing 11 is typically of the order of 5,000 hbars.

In other words, the Young's modulus of the linear 10 is considerably lower than that of the external casing 11 since it is about 10,000 times smaller.

Reference will be made more particularly to the diagram shown in Fig. 3 in which the abscissae, in hbars, show the elongation $\Delta l/l$ that is to say, the percentage of the increase in length achieved under load.

The straight line C shows the variations in elongation in dependence on pressure. Cl shows the point representing a degree of elongation of one thousandth corresponding to a thousandth of the Young's modulus of the elastomer forming the liner 10, that is to say, 0.07 divided by a thousand, that is to say: $0.7 \times 10^{-4}$. In the same way, R shows the straight line representing the variations in elongation of the casing 11 in dependence on load and more particularly point R1 represents a degree of elongation of a thousandth, corresponding to the Young's modulus of 5,000, divided by a thousand, which corresponds to an absicissa of 5. It will be seen that the slope of straight line C corresponding to the elastomer liner 10 is greater than the slope of the straight line R which corresponds to the casing 11, consisting of a winding of fibres encased in a binder.

Fig. 3 also shows at C' the straight line which would represent the variations in elongation in dependence on load if the internal liner were of steel and not elastomer, for example a steel having a Young's modulus of 20,000 hbars. It will be seen that, in this case, the slope of the straight line C' is not greater but smaller than the slope of the straight line R. When the casing is formed by fibres which are wound in a prestressed condition around the liner, the straight R is displaced and takes up the position shown at R'. In that case, it appears that, with such a liner made of steel and such a prestressed casing, the double wall of the vessel is subjected to rather precarious conditions in respect of strength, in particular when the pressure is widely variable, while in addition the steel liner may be subject to buckling and may run the risk of compromising the resistance of the vessel and the components thereof.

Those disadvantages are not incurred in the arrangement according to the invention, with a liner 10 of elastomer material and a non-prestressed external casing 11 in the form of binder-encased fibres wound around the liner 10.

Therefore, constructing the double wall structure 10, 11 with the elastomer liner 10 makes it possible to make optimum use of the mechanical properties of the external casing 11, the elongation to rupture of elastomers being in terms of hundreds of percent. The elastomer forming the liner 10 therefore makes virtually no contribution to the mechanical strength of the double wall 10, 11 such strength being provided virtually entirely by the casing 11. The thickness of the elastomer liner 10 is defined by the minimum value compatible with the manufacturing process. To give a specific idea in this respect, the thickness of the external casing is between 2 and 10 times and preferably close to 6 times the thickness of the internal liner. The specific gravity of the internal liner 10 is advantageously of the order of 2.

The arrangement according to the present invention therefore appears to be an optimum arrangement in regard to elongation and resistance to pressures and more particularly, if appropriate, to cycles of pressures.

In addition, manufacture of the pressure vessel according to the invention is particularly simple and convenient.

The liner 10 is made of elastomer, using any suitable process. The liner 10 comprises a tube, the ends of which are closed to the members 14 and 16.

The elastomer liner 10 is threaded onto a mandrel, either mechanical, for example a mandrel of extensible type of any suitable type, or a mandrel comprising lost material, for example sand or wax. The mandrel advantageously comprises a central axis and can thus be driven in rotation for winding fibres around the axis of symmetry. The metal members 14 and 16 form inserts which are caused to adhere to the elastomer liner 10 before that operation, in any suitable manner. The binder-impregnated fibres are fixed rigidly to the liner 10. There is therefore excellent adhesion between the liner 10 and the casing 11.

After setting of the binder and removal of the mandrel, the pressure vessel is ready for use. Where the pressure vessel is to serve as a hydropneumatic accumulator or pressure transmitter (Fig. 2), the bladder assembly 19, 25 can be introduced into the pressure vessel by known techniques. For example the upper metal fitting 16 may be made in two parts, a radially inner part, which is removably secured, for example by screw-threads, to an outer part which is bonded in the end 13 of the casing 11, the inner diameter of the outer part being large enough to admit the bladder 10 and valve member 25 when the inner part is removed.

## CLAIMS

1. A pressure vessel having a double wall which comprises an internal liner reinforced by an external casing, in which said external casing is adapted on its own to provide substantially all the mechanical strength of the double wall, and the internal liner has a Young's modulus selected at a lower value than that of the external casing and primarily performs a sealing function.

2. A pressure vessel according to claim 1 wherein the internal liner vessel is of elastomer.

3. A pressure vessel according to claim 1 or 2 wherein the external casing is free from prestress.

4. A pressure vessel according to any of claims 1 to 3 wherein the external casing comprises fibres which are wound around the internal liner and encased in a binder.

5. A pressure vessel according to any of the preceding claims wherein the thickness of the external casing is from 2 to 10 times the thickness of the internal liner.

6. A pressure vessel according to claim 5 wherein the thickness of the external casing is substantially six times the thickness of the internal liner.

7. A pressure vessel according to any of the preceding claims in which the external casing comprises filaments of glass, graphite or polyamide and a binder of epoxy resin, polyester or polyimide.

8. A pressure vessel according to any of the preceding claims and including a flexible separator dividing the interior of the vessel into two chambers communicating with respective parts in the vessel wall.

9. A pressure vessel substantially as described with reference to Figure 1 or Figure 2 of the drawings.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1984.
Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY, from which copies may be obtained.